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Araucaria heterophylla (Salisb.) Franco Norfolk-Island-pine

Araucariaceae Araucaria family

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HABITAT

Native Range

Araucaria heterophylla, (Salisb.) Franco, commonly known as Norfolk-Island-pine, is native only to Norfolk Island, a small, windswept island situated at 29 °S in the Pacific 1450 km east of Australia (fig. 1) (*12*). Since the Island's discovery in 1774, the species has been spread all over the world. Prized for its stately shape (fig. 2) and rich green foliage, it is cultivated as an ornamental in most tropical and subtropical countries and as a potted plant in temperate areas. Norfolk-Island-pine is reported to have become naturalized in Queensland, Australia (*15*), and Hawaii, and has been successfully grown in Costa Rican (*5*), and South African timber trials (*12*).

Climate

The climate of Norfolk Island is subtropical and uniform. Extreme temperatures range from 7 to 27 °C (*2*). Annual rainfall, which averages 1320 mm, is evenly distributed throughout the year, although occasional summer droughts have been recorded. Outside the home range, the species tolerates a wide range in quantity and distribution of precipitation. In Zimbabwe, it grows at elevations ranging from 900 to 1500 m, with mean annual rainfall as low as 889 mm (*16*). In Queensland, where it is extensively planted, precipitation ranges from 1016 to 2032 mm per year. Norfolk-Island-pine loses its healthy green appearance in areas that average less than 940 mm annual precipitation. In Puerto Rico, ornamental trees thrive in areas where precipitation exceeds 2500 mm per year. Both hot and cool temperatures are tolerated; however, Norfolk-Island-pine is damaged by heavy frosts (*16*).

Soils and Topography

Norfolk-Island-pine grows throughout Norfolk Island, a volcanic island with a maximum elevation of a little over 300 m (*2*). There are both flat fields and steep cliffs. The soils are mostly red Ultisols that originated from basalt and tuff parent material. The soils are fertile enough for good forest growth, although nutrient deficiencies have developed following cultivation when land was cleared for agricultural crops (*17*).

In exotic environments, the Norfolk-Island-pine grows well on soils ranging in texture from clay (*13*) to almost pure sand (*3*). In Puerto Rico, moderately alkaline (pH 8.0) to strongly acidic soils (pH 4.5) are tolerated. Good drainage is necessary (*8*). Its ability to grow on coastlines is well known. The species also grows in interior areas of Africa (*16*). In the Philippines, it grows well up to a 1524-m elevation (*12*).

Associated Forest Cover

On Norfolk Island, Norfolk-Island-pine competes with other vegetation successfully on a range of sites. In the harsh coastal environment, it grows with *Lagunaria patersoni* G. Don, which assumes extreme windswept forms (*2*). In disturbed upland areas, a dense xeromophic vegetation that includes *Rhodomyrtus psidioides* Benth., *Olea africana* Mill., *Schinus terebinthifolius* Raddi, and *Lantana camara* L. develops with Norfolk-Island-pine. It also becomes a dominant in dense rain forests where hardwood associates include: *Olea apetala* Vahl., *Elaeodendron curtipendulum* Endl., *Zanthoxylum blackburnia* Benth., *Baloghia lucida* Endl., and *Pseudomorus brunoniana* Bur. (*14*).

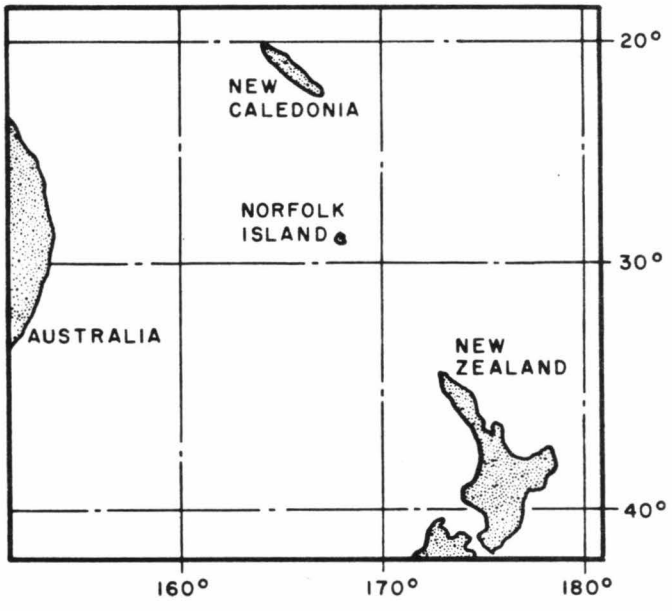

Figure 1.—*Location of Norfolk Island (native range of Norfolk-Island-pine) in the South Pacific.*

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LIFE HISTORY

Reproduction and Early Growth

Flowering and Fruiting.—Norfolk-Island-pine is mostly dioecious (producing male and female flowers on different trees) (*1*). The male cones are 4 to 5 cm long and the female cones have many scales, are rounded, and are 10 to 13 cm long (*9*).

Seed Production and Dissemination.—The cones fall apart at maturity, releasing winged scales with attached, oblong, 3-cm seeds. Fresh seeds number about 1,137 seeds/kg and may dry to 1,265 seeds/kg without loosing viability (*10*). On Norfolk Island, good seed crops are produced every 4 to 6 years (*2*).

Seedling Development.—Seeds sprout epigeally (*1*), beginning about 5 days after contacting a continuously moist surface (*10*). Fresh seeds may give 70-percent germination and retain good viability for a month or so at ambient temperatures, after which germination percentage decreases rapidly. The optimum storage temperature has been shown to be about 7 °C under a relative humidity of 60 to 75 percent (*12*). Excessive drying of seeds results in poor germination (*10*). The seeds require surface germination or a very light covering of soil or duff (*10*). If the covering is substantial, the weak stems will not be able to raise the seed capsule. Partial shade is beneficial during the germination and early seedling stage. Seeds for production of seedlings for ornamental or forestry purposes are available from Norfolk Island Territory, the Canary Islands, Peru, and Brazil (*10*). Hawaii also produces seeds, but most are actually *A. columnaris* Hook., a species native to the Cook Islands[1].

Although one reference (*16*) suggests using rooted cuttings when starting Norfolk-Island-pine for ornamental purposes due to the long internodes of seedlings, at least one commercial nursery regularly produces ornamental stock from seed (*10*). Seedlings are the preferred planting stock for forestry purposes. New plants are grown for 1 to 2 years in seedbeds and then transplanted to pots or other containers in which they are sold. Seedlings attain a 15- to 20-cm height by the end of the first year and a 61- to 76-cm height by the end of the second (*10*). In order to shorten the period of weeding required after outplanting, 1.5- or 2-year-old seedlings would be preferable for forest plantings. Although only conventional solid plantations are reported (*1, 6*), line, gap, and underplanting systems are probably workable.

Vegetative Reproduction.—Norfolk-Island-pines are propagated commercially from terminal shoot cuttings as well as from seeds. Shoots will root without growth hormone treatments, but the best results will be obtained by using indolacytic acid (IBA) or idolacytic acid (IAA) (*12*) and a fungicide (*10*). Shoots from plants 15 cm tall growing under shade and misted twice a day will strike roots in about 90 days, whereas shoots from plants 1.2 m or more in height require a year, if they root at all (*10*). Plants with three or four tiers of branches will produce multiple leader shoots after tip cuttings are removed. After the tip cuttings are harvested, the whorl is removed and the next lower whorl then produces multiple leaders. Cuttings from branch tips will root readily, but they always retain a flat asymmetrical habit (*6*). Young trees (Christmas trees) can renew themselves by sprouting new leaders if two whorls of live branches are left when the top is harvested (*8*). Although grafting of Norfolk-Island-pine has not been reported, grafting has been done successfully with a related species, *A. cunninghamii* Ait. ex. D. Don (*11*).

Figure 2.—*Ornamental Norfolk-Island-pine growing in Puerto Rico.*

Sapling and Pole Stage to Maturity

Growth and Yield.—Height growth proceeds very slowly at first but gradually increases with age. Sixteen 46-cm high seedlings in Hawaii grew an average of 1.7 m the first 2 years after outplanting (*8*). A plantation in South Africa with 1,235 stems/ha in an area with moderately deep loam, 1499 mm precipitation, 518 m elevation, and subject to light frosts had a mean height of 18.3

[1]Personal communication with Craig Whitesell, Pacific Islands Forestry, USDA Forest Service, Honolulu, Hawaii.

m and a d.b.h. of 19.3 cm when 18 years old (*12*). A small 15-year-old plantation in Puerto Rico (29 trees) ranged in height from 8 to 20 m and had d.b.h.'s from 10 to 25 cm. Also in Puerto Rico, 40 ornamental Norfolk-Island-pines ranging from 7 to 30 years in age growing across an altitude (sea level to 400 m) and rainfall (915 mm, with possible supplemental irrigation, to 2030 mm) gradient, averaged 1.00 ± 0.17 m in annual height growth and 1.99 ± 0.37 cm in annual d.b.h. growth. No significant difference was found between the four Puerto Rico sites. Height growth rates of ornamental trees were predicted using homeowner-recalled age (fig. 3). Fifteen 25- to 49-year-old small test plantations of putative hybrids *A. heterophylla* X *columnaris* in five areas in Hawaii were reported with spacings from 3 by 3 m to 4.3 by 4.6 m (*4*). The plot with the largest trees (dominants and codominants) had trees that averaged 34.4 m in height and 40.6 cm in d.b.h. Mean annual volume increment ranged from 11 to 28 m^3/ha/yr. Survival was a remarkable 100 percent. A small 10-year-old plantation in Costa Rica had a survival of 47 percent and an average d.b.h. of 19.9 cm (*13*). An even-aged 67-year-old stand on Norfolk Island had a mean height of 41.6 m and a mean d.b.h. of 50.1 cm (*2*). Average annual diameter increment for the last 9 years had been 0.32 cm. On Norfolk Island this species makes fairly steady growth for 80 years with a maximum height of 55 m (*2*). The oldest living trees are now about 150 years-old. Norfolk-Island-pines grow with symmetrical form for about 30 years, after which the top begins to flatten out. Very old trees are often broken-topped and hollow.

Rooting Habit.—Seedlings produce a tap root and numerous fiberous laterals. Older trees do not grow massive near-surface lateral roots and thus rarely cause damage to sidewalks or building foundations. Older trees may be enlarged somewhat at the base or produce small, broad buttresses (*9*).

Reaction to Competition.—Norfolk-Island-pine is shade tolerant. Although seedlings do not grow under the very dense stands of parent trees or under primary rain forest canopies, when overstory trees die here and there, and a little extra light enters the understory, seedlings will become established, persist, and eventually dominate broadleaf competitors (*2*). The process may take as long as 40 years.

In the first years after planting, clean cultivation is desirable, but later a ground cover of low herbs and grasses is probably not detrimental (*8*). Vines and overtopping hardwood sprouts should be controlled. Initial spacings of 3 by 3 m with midrotation thinning is recommended (*4*). No exact rotation lengths have been suggested, but the optimum must lie between 30 years, when stands begin to produce small saw logs, and 80 years, when growth begins to slow.

Two stands were inventoried on Norfolk Island. One, a 67-year-old even-aged stand, had 346 trees/ha and a basal area of 68 m^2/ha (*2*). Periodic basal area increments for the last 9 years for the two stands were 0.82 and 0.83 m^2/ha, respectively.

Damaging Agents.—The most serious disease of Norfolk-Island-pine in its native habitat is dieback, the cause of which is still unknown. This slowly progressing

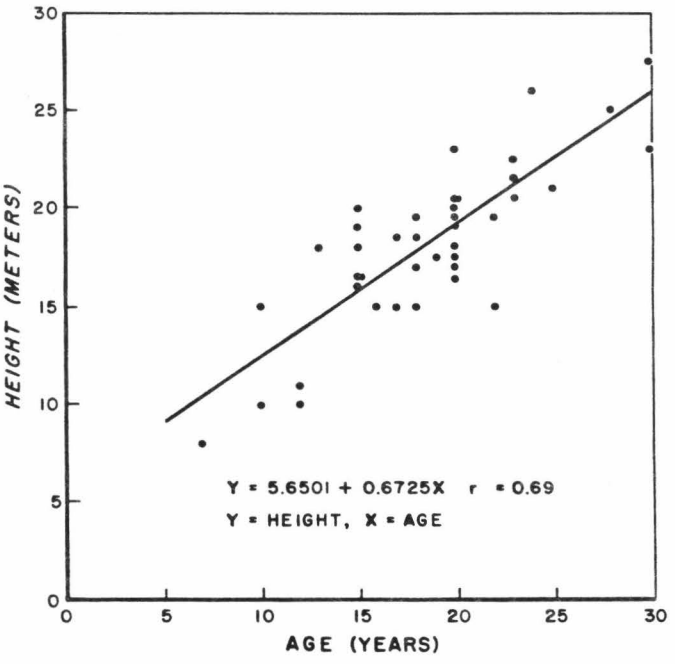

Figure 3.—*Heights of ornamental Norfolk-Island-pines in Puerto Rico, predicted from age.*

deterioration of crowns is associated with stands on former agricultural land with heavy competition from introduced shrubs and grasses and on lands that are overgrazed (*2*). The disease has affected many of the scenic stands in the interior of the Island, but has left the steep, coastal areas unaffected.

A mealybug, *Octaspidiotus araucariae*, native to New Caledonia has infested Norfolk-Island-pine in Hawaii and Puerto Rico (*18*). The damage does not appear to be serious, however. In Brazil, *Eriococus araucariae* Muskell, which normally attacks *A. angustifolia* Bert. (O. Kuntze), has been noted on Norfolk-Island-pine ornamentals (*19*).

Norfolk-Island-pine is windfirm (*12*) and very resistant to salt spray.

SPECIAL USES

By far the greatest use of the species worldwide is as an ornamental. It is prized for its tall symmetry and deep green foliage. On Norfolk Island, where tourism is now surpassing other sources of income, the "pines" are an integral part of the breathtaking scenery (*2*). Some timber is extracted for local consumption. The trees provide shelter for livestock and help prevent erosion and landslides.

The wood of Norfolk-Island-pine is cream to light tan in color and has a density of 0.44g/cm^3 (*7*). Shrinkage from green to ovendry wood is 3.5 percent radially and 0.27 percent longitudinally. The wood is stiff, moderately strong in both bending and compressive strength, and moderately hard, roughly comparable to Douglas-fir. Younger trees tend to be very knotty. While this may lower the wood's value for many traditional uses, the trait can be turned to an advantage by using it for "knotty pine" furniture and paneling.

GENETICS

Little is known of the genetics of Norfolk-Island-pine. The genus *Araucaria* contains 14 species. At least four widely scattered members of this genus have the chromosome number 2N = 26 (*12*); Norfolk-Island-pine probably is no different. Several horticultural varieties exist but are not very distinct from one another (*6*). The species most closely related to *A. heterophylla* is *A. columnaris*, which Norfolk-Island-pine resembles and with which it is alleged to freely hybridize, giving rise to the race (*A. heterophylla* X *columnaris*) of naturalized trees found in Hawaii (*4*). Others[1] feel that these naturalized trees are simply *A. columneris*. No research has been performed to establish either opinion.

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